PHOENIX LAKE IRWM RETROFIT

Attachment 9 - Water Quality and Other Expected Benefits

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1.0 Description of the Water Quality, Ecosystem Restoration, and Recreation and Public Access Projects and Their Relationships to Other Projects

This section describes the facility components and benefits for each of the Water Quality, Ecosystem Restoration, and Recreation and Public Access Projects and its relationship to other projects.

1.1 Description of the Water Quality Project and Its Relationship to Other Projects

The Water Quality Project component of the Phoenix Lake IRWM Retrofit consists of installing two circulation devices (such as SolarBee© or other similar type of circulation device) to address the water quality issues in the lake: (1) epilimnetic circulation device and (2) hypolimnetic circulation device. The eplimnetic circulation device is designed to reduce the growth of floating algae and thereby improve water quality, lake clarity, and reduce treatment costs, particularly during the summertime when lake supply is most needed. The hypolimnetic circulation device aims to oxygenate the hypolimnion and prevent dissolution of sediment-bound metals (e.g., iron and manganese). Oxygenating the hypolimnion is intended to enlarge the lake’s suitable coldwater habitat volume and thereby improve the trout fishery. These two circulation devices will be carefully designed so that the thermal structure of the lake (i.e., stratification) will not be affected. Maintaining the lake’s stratification is important to preserve cool water in the hypolimnion for release to Ross Creek through the low-level drain pipe intake control gate which is included in the Ecosystem Restoration Project.

The two circulation devices will also work synergistically with other component projects of the Phoenix Lake IRWM Retrofit to enhance their benefits, as summarized in Table 1 below.

Table 1 Relationship of the Water Quality Project to Other Projects Comprising the Phoenix Lake IRWM Retrofit

Other Project	Relationship of the Water Quality Project to Other Projects
Flood Damage Reduction Project	None
Water Supply Project	The epilimnetic circulation device also enhances water supply by improving lake water quality for drinking water use.
Ecosystem Restoration Project	The hypolimnetic circulation device also enhances ecosystem restoration of Ross Creek by increasing dissolved oxygen in the instream flow releases through the low-level drain pipe intake control valve.
Recreation and Public Access Project	The epilimnetic circulation device also enhances public recreation by improving lake clarity and reducing invasive aquatic vegetation and adding to lake’s aesthetic appeal. The hypolimnetic circulation device also enhances public recreation by increasing dissolved oxygen in the hypolimnion and enlarging the lake’s suitable coldwater habitat volume thereby improving the trout fishery.

1.2 Description of the Ecosystem Restoration Project and Its Relationship to Other Projects

The Ecosystem Restoration Project component of the Phoenix Lake IRWM Retrofit consists of incorporating a low flow control gate into the design of the Flood Damage Reduction Project's low-level drain pipeline intake.

Under current operations, the existing 30" pipe low-level outlet is normally kept closed. Outflow from the lake to downstream is provided by spillway overflows, and these outflows derive from the warm surface layer of the lake. Installing a low flow control gate allows precisely controlled low flow release of cool water drawn from the lake hypolimnion via the 140 ft level intake. Release of cool water from the lake hypolimnion will improve downstream water quality (i.e., water temperature) and aquatic habitat for target salmonids and other coldwater species. Without the Phoenix Lake IRWM Retrofit, recovery of target salmonids and other species in Ross Creek and lower Corte Madera Creek will continue to be challenged by sub-optimal riparian and aquatic habitat conditions.

The Ecosystem Restoration Project also works synergistically with other component projects of the Phoenix Lake IRWM Retrofit to enhance their benefits, as summarized in Table 2 below.

Table 2 Relationship of the Ecosystem Restoration Project to Other Projects Comprising the Phoenix Lake IRWM Retrofit

Other Project	**Relationship of the Ecosystem Restoration Project to Other Projects**
Flood Damage Reduction Project	None
Water Supply Project	None
Water Quality Project	Enhances downstream water quality by improving coldwater beneficial use of Ross Creek and lower Corte Madera Creek
Recreation and Public Access Project	Enhanced aquatic habitat could increase native fish populations thereby enhancing wildlife viewing opportunities and general public enjoyment along Ross Creek in Natalie Coffin Greene Park below Phoenix Lake

1.3 Description of the Recreation and Public Access Project and Its Relationship to Other Projects

The Recreation and Public Access Project component of the Phoenix Lake IRWM Retrofit consists of:

1) Replacing a non-functioning stream crossing on Bill Williams Creek with a multi-plate arch culvert to provide fish passage, reduce erosion and improve access.
2) Improve trail conditions in the upper Ross Creek watershed to reduce erosion and sediment delivery, and to improve access and visitor safety.
3) Provide public facilities such as bathrooms, benches, and informational kiosks around Phoenix Lake to enhance the user experience, provide public education, and lessen user impacts to the surrounding environment.
4) Reduce erosion and sediment delivery to Ross Creek and its tributaries, and improve public access and safety by stormproofing maintenance and emergency access roads in the watershed.

The Recreation and Public Access Project also works synergistically with other component projects of the Phoenix Lake IRWM Retrofit to enhance their benefits, as summarized in Table 3 below.

Table 3 Relationship of the Recreation and Public Access Project to Other Projects Comprising the Phoenix Lake IRWM Retrofit

Other Project	**Relationship of the Recreation and Public Access Project to Other Projects**
Flood Damage Reduction Project	Reduces erosion and sediment delivery/sedimentation in the lake and maintains lake storage capacity for flood attenuation
Water Supply Project	Reduces erosion and sediment delivery/sedimentation in the lake and maintains lake storage capacity for water supply
Water Quality Project	Reduces sediment delivery and pollutant loading thereby improving lake water quality
Ecosystem Restoration Project	None

2.0 Description of Economic Costs of the Water Quality, Ecosystem Restoration, and Recreation and Public Access Projects

Economic costs associated with the Water Quality, Ecosystem Restoration, and Recreation and Public Access Projects include initial capital costs of the facility elements and future operations and maintenance costs. Initial capital costs of the Water Quality Project, the Ecosystem Restoration Project, and the Recreation and Public Access Project are detailed in Attachment 4, Budget. These initial capital costs cover all costs associated with initial project implementation including a) direct project administration, b) land purchase and easement (none will be required), c) planning, design, engineering, and environmental documentation, d) construction and implementation, e) environmental compliance, mitigation, and enhancement, f) construction administration, g) other costs, and h) construction and implementation contingency (25%).

Future operations and maintenance costs are recurring costs that are incurred over the life of the Project elements. Annual costs include administration, operation, maintenance, replacement and repairs, and others such as monitoring and inspections and reporting. Annual costs are estimated as a percentage of the construction cost[1] (2% for the Water Quality Project, 1% for the Ecosystem Restoration Project, and 1% for the Recreation and Public Access Project).

Tables 4, 5, and 6 show the cost details of the initial capital costs and future operations and maintenance costs for the Water Quality Project, the Ecosystem Restoration Project, and the Recreation and Public Access Project, respectively. It was assumed that the useful lifetime for the Water Quality Project components (i.e., two circulation devices) is 25 years (see Appendix 7 of Attachment 3, Work Plan), and for the Ecosystem Restoration Project and the Recreation and Public Access Project components is 50 years.

Table 4 shows that capital costs for the Water Quality Project amount to about $382,000 (2009 dollars). The capital costs will be incurred in 2012 through 2016 and distributed according to the schedule of Attachment 5. Capital costs that were already expended in the past are considered sunk costs and are not included in this analysis. The incremental costs associated with project administration, operation, maintenance, replacement, and others (i.e., performance monitoring) amount to a total of about $210,000 (non-discounted 2009 dollars) over the useful lifetime of the project (assumed 25 years). Together, the present value capital and O&M costs for the Water Quality Project at 6% discount rate amount to about $363,000 through 2041.

Table 5 shows that capital costs for the Ecosystem Restoration Project amount to about $271,000 (2009 dollars). The incremental costs associated with project administration, operation, maintenance, replacement, and others (i.e., performance monitoring) amount to about $210,000 (non-discounted 2009 dollars) over the useful lifetime of the project (assumed 50 years). Together, the present value capital and O&M costs for the Ecosystem Restoration Project at 6% discount rate amount to a total of about $303,000 through 2065.

Table 6 shows that capital costs for the Recreation and Public Access Project amount to about $1,810,000 (2009 dollars). The incremental costs associated with project administration, operation, maintenance, replacement, and others (i.e., performance monitoring) amount to about $522,500 (non-discounted 2009 dollars) over the useful lifetime of the project (assumed 50 years). Together, the present value capital and O&M

[1] Refer to the construction cost estimation tables in sections 3.3.2, 3.4.2, and 3.5.2 of Attachment 3, Work Plan for the Water Quality Project, the Ecosystem Restoration Project, and the Recreation and Public Access Project, respectively. The 2%, 1%, and 1% were applied to the construction cost excluding the cost for general requirements.

costs for the Recreation and Public Access Project at 6% discount rate amount to about $1,420,000 through 2065.

Table 4 Annual Cost of Water Quality Project (in 2009 Dollars)
Project: Phoenix Lake IRWM Retrofit Project – Water Quality Project

	Initial Costs	Operation and Maintenance Costs (1)							
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Year	Grand Total Costs	Admin	Operation	Maintenance	Replacement	Other	Total Costs (a) +…+ (f)	Discount Factor (2)	Discounted Costs (g) × (h)
2009								1.000	
2010								0.943	
2011								0.890	
2012	$5,000						$5,000	0.840	$4,200
2013	$17,000						$17,000	0.792	$13,464
2014	$4,000						$4,000	0.747	$2,988
2015	$23,000						$23,000	0.705	$16,215
2016	$333,000						$333,000	0.665	$221,445
2017		$600	$600	$600	$600	$30,000	$32,400	0.627	$20,315
2018		$600	$600	$600	$600	$30,000	$32,400	0.592	$19,181
2019		$600	$600	$600	$600	$30,000	$32,400	0.558	$18,079
2020		$600	$600	$600	$600	$30,000	$32,400	0.527	$17,075
2021		$600	$600	$600	$600	$30,000	$32,400	0.497	$16,103
2022		$600	$600	$600	$600		$2,400	0.469	$1,126
2023		$600	$600	$600	$600		$2,400	0.442	$1,061
2024		$600	$600	$600	$600		$2,400	0.417	$1,001
2025		$600	$600	$600	$600		$2,400	0.394	$946
2026		$600	$600	$600	$600		$2,400	0.371	$890
2027		$600	$600	$600	$600		$2,400	0.350	$840
2028		$600	$600	$600	$600		$2,400	0.331	$794
2029		$600	$600	$600	$600		$2,400	0.312	$749
2030		$600	$600	$600	$600		$2,400	0.294	$706
2031		$600	$600	$600	$600		$2,400	0.278	$667
2032		$600	$600	$600	$600		$2,400	0.262	$629
2033		$600	$600	$600	$600		$2,400	0.247	$593
2034		$600	$600	$600	$600		$2,400	0.233	$559
2035		$600	$600	$600	$600		$2,400	0.220	$528
2036		$600	$600	$600	$600		$2,400	0.207	$497
2037		$600	$600	$600	$600		$2,400	0.196	$470
2038		$600	$600	$600	$600		$2,400	0.185	$444
2039		$600	$600	$600	$600		$2,400	0.174	$418
2040		$600	$600	$600	$600		$2,400	0.164	$394
2041		$600	$600	$600	$600		$2,400	0.155	$372
Project Life	$382,000	$15,000	$15,000	$15,000	$15,000	$150,000	$592,000		
Total Present Value of Discounted Costs (Sum of Column (i))									**$363,000**

(1) The incremental change in O&M costs attributable to the project; (2) 6% discount rate.

Table 5 Annual Cost of Ecosystem Restoration Project (in 2009 Dollars) Project: Phoenix Lake IRWM Retrofit Project – Ecosystem Restoration Project									
	Initial Costs	**Operation and Maintenance Costs (1)**							
	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**
Year	**Grand Total Costs**	**Admin**	**Operation**	**Maintenance**	**Replacement**	**Other**	**Total Costs (a) +…+ (f)**	**Discount Factor (2)**	**Discounted Costs (g) × (h)**
2009								1.000	
2010								0.943	
2011	$5,000						$5,000	0.890	$4,450
2012	$22,000						$22,000	0.840	$18,480
2013	$41,000						$41,000	0.792	$32,472
2014	$36,000						$36,000	0.747	$26,892
2015	$168,000						$168,000	0.705	$118,440
2016		$300	$300	$300	$300	$30,000	$31,200	0.665	$20,748
2017		$300	$300	$300	$300	$30,000	$31,200	0.627	$19,562
2018		$300	$300	$300	$300	$30,000	$31,200	0.592	$18,470
2019		$300	$300	$300	$300	$30,000	$31,200	0.558	$17,410
2020		$300	$300	$300	$300	$30,000	$31,200	0.527	$16,442
2021		$300	$300	$300	$300		$1,200	0.497	$596
2022		$300	$300	$300	$300		$1,200	0.469	$563
2023		$300	$300	$300	$300		$1,200	0.442	$530
2024		$300	$300	$300	$300		$1,200	0.417	$500
2025		$300	$300	$300	$300		$1,200	0.394	$473
2026		$300	$300	$300	$300		$1,200	0.371	$445
2027		$300	$300	$300	$300		$1,200	0.350	$420
2028		$300	$300	$300	$300		$1,200	0.331	$397
2029		$300	$300	$300	$300		$1,200	0.312	$374
2030		$300	$300	$300	$300		$1,200	0.294	$353
2031		$300	$300	$300	$300		$1,200	0.278	$334
2032		$300	$300	$300	$300		$1,200	0.262	$314
2033		$300	$300	$300	$300		$1,200	0.247	$296
2034		$300	$300	$300	$300		$1,200	0.233	$280
2035		$300	$300	$300	$300		$1,200	0.220	$264
2036		$300	$300	$300	$300		$1,200	0.207	$248
2037		$300	$300	$300	$300		$1,200	0.196	$235
2038		$300	$300	$300	$300		$1,200	0.185	$222
2039		$300	$300	$300	$300		$1,200	0.174	$209
2040		$300	$300	$300	$300		$1,200	0.164	$197
2041		$300	$300	$300	$300		$1,200	0.155	$186
2042		$300	$300	$300	$300		$1,200	0.146	$175
2043		$300	$300	$300	$300		$1,200	0.138	$166
2044		$300	$300	$300	$300		$1,200	0.130	$156
2045		$300	$300	$300	$300		$1,200	0.123	$148
2046		$300	$300	$300	$300		$1,200	0.116	$139
2047		$300	$300	$300	$300		$1,200	0.109	$131
2048		$300	$300	$300	$300		$1,200	0.103	$124
2049		$300	$300	$300	$300		$1,200	0.097	$116
2050		$300	$300	$300	$300		$1,200	0.092	$110
2051		$300	$300	$300	$300		$1,200	0.087	$104
2052		$300	$300	$300	$300		$1,200	0.082	$98
2053		$300	$300	$300	$300		$1,200	0.077	$92
2054		$300	$300	$300	$300		$1,200	0.073	$88
2055		$300	$300	$300	$300		$1,200	0.069	$83
2056		$300	$300	$300	$300		$1,200	0.065	$78
2057		$300	$300	$300	$300		$1,200	0.061	$73
2058		$300	$300	$300	$300		$1,200	0.058	$70
2059		$300	$300	$300	$300		$1,200	0.054	$65
2060		$300	$300	$300	$300		$1,200	0.051	$61
2061		$300	$300	$300	$300		$1,200	0.048	$58
2062		$300	$300	$300	$300		$1,200	0.046	$55
2063		$300	$300	$300	$300		$1,200	0.043	$52
2064		$300	$300	$300	$300		$1,200	0.041	$49
2065		$300	$300	$300	$300		$1,200	0.038	$46
Project Life	$271,000	$15,000	$15,000	$15,000	$15,000	$150,000	$481,000		
Total Present Value of Discounted Costs (Sum of Column (i))									**$303,000**

(1) The incremental change in O&M costs attributable to the project; (2) 6% discount rate

Table 6 Annual Cost of Recreation and Public Access Project (in 2009 Dollars)
Project: Phoenix Lake IRWM Retrofit Project – Recreation and Public Access Project

	Initial Costs	Operation and Maintenance Costs [1]							
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Year	Grand Total Costs	Admin	Operation	Maintenance	Replacement	Other	Total Costs (a) +…+ (f)	Discount Factor [2]	Discounted Costs (g) × (h)
2009								1.000	
2010								0.943	
2011	$55,000						$55,000	0.890	$48,950
2012	$70,000						$70,000	0.840	$58,800
2013	$46,000						$46,000	0.792	$36,432
2014	$68,000						$68,000	0.747	$50,796
2015	$1,571,000						$1,571,000	0.705	$1,107,555
2016		$2,600	$2,600	$2,600	$2,600	$500	$10,900	0.665	$7,249
2017		$2,600	$2,600	$2,600	$2,600	$500	$10,900	0.627	$6,834
2018		$2,600	$2,600	$2,600	$2,600	$500	$10,900	0.592	$6,453
2019		$2,600	$2,600	$2,600	$2,600	$500	$10,900	0.558	$6,082
2020		$2,600	$2,600	$2,600	$2,600	$500	$10,900	0.527	$5,744
2021		$2,600	$2,600	$2,600	$2,600		$10,400	0.497	$5,169
2022		$2,600	$2,600	$2,600	$2,600		$10,400	0.469	$4,878
2023		$2,600	$2,600	$2,600	$2,600		$10,400	0.442	$4,597
2024		$2,600	$2,600	$2,600	$2,600		$10,400	0.417	$4,337
2025		$2,600	$2,600	$2,600	$2,600		$10,400	0.394	$4,098
2026		$2,600	$2,600	$2,600	$2,600		$10,400	0.371	$3,858
2027		$2,600	$2,600	$2,600	$2,600		$10,400	0.350	$3,640
2028		$2,600	$2,600	$2,600	$2,600		$10,400	0.331	$3,442
2029		$2,600	$2,600	$2,600	$2,600		$10,400	0.312	$3,245
2030		$2,600	$2,600	$2,600	$2,600		$10,400	0.294	$3,058
2031		$2,600	$2,600	$2,600	$2,600		$10,400	0.278	$2,891
2032		$2,600	$2,600	$2,600	$2,600		$10,400	0.262	$2,725
2033		$2,600	$2,600	$2,600	$2,600		$10,400	0.247	$2,569
2034		$2,600	$2,600	$2,600	$2,600		$10,400	0.233	$2,423
2035		$2,600	$2,600	$2,600	$2,600		$10,400	0.220	$2,288
2036		$2,600	$2,600	$2,600	$2,600		$10,400	0.207	$2,153
2037		$2,600	$2,600	$2,600	$2,600		$10,400	0.196	$2,038
2038		$2,600	$2,600	$2,600	$2,600		$10,400	0.185	$1,924
2039		$2,600	$2,600	$2,600	$2,600		$10,400	0.174	$1,810
2040		$2,600	$2,600	$2,600	$2,600		$10,400	0.164	$1,706
2041		$2,600	$2,600	$2,600	$2,600		$10,400	0.155	$1,612
2042		$2,600	$2,600	$2,600	$2,600		$10,400	0.146	$1,518
2043		$2,600	$2,600	$2,600	$2,600		$10,400	0.138	$1,435
2044		$2,600	$2,600	$2,600	$2,600		$10,400	0.130	$1,352
2045		$2,600	$2,600	$2,600	$2,600		$10,400	0.123	$1,279
2046		$2,600	$2,600	$2,600	$2,600		$10,400	0.116	$1,206
2047		$2,600	$2,600	$2,600	$2,600		$10,400	0.109	$1,134
2048		$2,600	$2,600	$2,600	$2,600		$10,400	0.103	$1,071
2049		$2,600	$2,600	$2,600	$2,600		$10,400	0.097	$1,009
2050		$2,600	$2,600	$2,600	$2,600		$10,400	0.092	$957
2051		$2,600	$2,600	$2,600	$2,600		$10,400	0.087	$905
2052		$2,600	$2,600	$2,600	$2,600		$10,400	0.082	$853
2053		$2,600	$2,600	$2,600	$2,600		$10,400	0.077	$801
2054		$2,600	$2,600	$2,600	$2,600		$10,400	0.073	$759
2055		$2,600	$2,600	$2,600	$2,600		$10,400	0.069	$718
2056		$2,600	$2,600	$2,600	$2,600		$10,400	0.065	$676
2057		$2,600	$2,600	$2,600	$2,600		$10,400	0.061	$634
2058		$2,600	$2,600	$2,600	$2,600		$10,400	0.058	$603
2059		$2,600	$2,600	$2,600	$2,600		$10,400	0.054	$562
2060		$2,600	$2,600	$2,600	$2,600		$10,400	0.051	$530
2061		$2,600	$2,600	$2,600	$2,600		$10,400	0.048	$499
2062		$2,600	$2,600	$2,600	$2,600		$10,400	0.046	$478
2063		$2,600	$2,600	$2,600	$2,600		$10,400	0.043	$447
2064		$2,600	$2,600	$2,600	$2,600		$10,400	0.041	$426
2065		$2,600	$2,600	$2,600	$2,600		$10,400	0.038	$395
Project Life	$1,810,000	$130,000	$130,000	$130,000	$130,000	$2,500	$2,333,000		
Total Present Value of Discounted Costs (Sum of Column (i))									**$1,420,000**

(1) The incremental change in O&M costs attributable to the project; (2) 6% discount rate

3.0 Description of Economic Benefits of the Water Quality, Ecosystem Restoration, and Recreation and Public Access Projects

The following items are described in this section:

1) Methods used to estimate without- and with-Project conditions
2) Benefit estimates of without- and with-Project physical conditions
3) Other potential benefits
4) Distribution of Local, Regional, and State-Wide Benefits and Identification of Beneficiaries
5) When the benefits will be received
6) Uncertainty of the benefits
7) Any adverse effects

3.1 Description of Methods Used to Estimate Without- and With-Project Conditions

In this analysis, only the economic benefits of the Water Quality Project, in terms of avoided treatment costs, are estimated quantitatively. Due to the difficulty to accurately quantify the economic benefits of the Ecosystem Restoration Project and the Recreation and Public Access Project, the benefits of these two projects are described in physical terms.

Phoenix Lake is afflicted with floating algae blooms, particularly during summertime. This reduces water clarity and the overall aesthetic appeal of the lake to fishermen and other recreationalists who visit the lake. Algae also affect the filtration process and increase MMWD's costs to treat Phoenix Lake water at its Bon Tempe Treatment Plant. Low dissolved oxygen in the lake hypolimnion creates a potential for dissolution of sediment-bound metals (iron and manganese). The algae and low dissolved oxygen can lead to taste and odor problems in the treated drinking water. Currently MMWD manages algae blooms in some of its reservoirs through careful application of copper sulfate. Copper sulfate is typically used at a rate of 10 pounds per surface acre. Phoenix Lake has a surface area of about 17 acres at the existing normal lake level (el. 174 ft). This gives the copper sulfate dosage of each application at about 170 pounds. Assuming monthly applications for the months of June through September (4 applications per year), the total usage of copper sulfate per year is estimated to be about 680 pounds. The average market price of copper sulfate is about $4 per pound. The labor cost and other expenses for each application is about $300. This gives the cost of copper application at about $6 per pound. So, the annual cost of copper sulfate application for algae control is estimated to be approximately $4,080. This annual cost can be avoided by the circulation devices included in the Water Quality Project.

3.2 Description of the Estimates of Without-Project and With-Project Physical Conditions

As described above, without the Water Quality Project, MMWD could apply about 680 pounds of copper sulfate at a cost of about $4,080 per year for algae control. With the Water Quality Project, this annual cost could be avoided.

Without the Ecosystem Restoration Project, spillway overflow from the warm surface layer of the lake is the primary source of outflow from the lake to downstream. The warm surface layer of the lake during the summer has an average temperature of about 23°C. With the Ecosystem Restoration Project, water will be drawn and released from the cool hypolimnion of the lake which has an average water temperature of about 12°C (see Appendix 6 of Attachment 3, Work Plan for the observed water temperature profiles in Phoenix Lake). It is anticipated that the Ecosystem Restoration Project will reduce the water temperature in Ross Creek immediately below Phoenix Lake Dam by about 11°C. Note that this temperature reduction benefit does not consider the effects of seepage through the dam.

Without the Recreation and Public Access Project, road-related erosion will continue to be a major source of sediment affecting water quality and aquatic habitats of Phoenix Lake and its tributaries. In 2003, Pacific Watershed Associates (PWA, 2003) completed a comprehensive assessment of erosion and sediment sources in MMWD’s Mt. Tamalpais watershed, with particular focus on the area’s roads and trails. In the Phoenix Lake watershed, PWA quantified the amount of sediment that could be delivered to Phoenix Lake and its tributaries from the road and trail network through catastrophic and chronic erosional processes. Catastrophic erosion includes episodic events, such as stream crossing failures, and debris slides, where a mass of sediment may be delivered to a stream in a relatively short period of time. Chronic erosion takes place on bare soils, such as unpaved roads that are exposed to rainsplash and runoff, which dislodges and transports particles downslope and downstream, effectively lowering the bare surface overtime. Chronic erosion is quantified on a decadal scale and uses lowering rates derived from local soils and geology. According to PWA (2003), Bill Williams Road, Filter Plant Road, and Lower Eldridge Grade have the potential to yield 4,888 cubic yards of sediment from catastrophic erosion events, and 2,442 cubic yards through chronic erosion over the next decade, while trails within the Phoenix Lake watershed have the potential to yield 1,014 cubic yards of sediment.

By completing the Bill Williams Culvert Project, Phoenix Lake Watershed Trail Improvement Project, and the Road-Related Sediment Control Project, over 8,300 cubic yards of sediment may be prevented from entering Phoenix Lake and its tributary streams over the next decade, with an annual average of 830 cubic yards of sediment. This will improve water quality in and upstream of Phoenix Lake, and will help ensure that the capacity of Phoenix Lake is not reduced by anthropogenic sources of sediment. These projects will also improve the conditions of the roads and trails, enhancing recreational opportunities and improving visitor safety and access.

Table 7 is a summary of water quality and other expected benefits. The benefits of the Water Quality Project are presented in economic terms and the benefits for the Ecosystem Restoration Project and the Recreation and Public Access Projects are presented in physical terms. Considering the useful life of 25 year for the Water Quality Project and 50 years for the Ecosystem Restoration Project and the Recreation and Public Access Project, the economic benefit for the Water Quality Project is calculated from the time the project comes online (2016) through 2041. The physical benefits for the Ecosystem Restoration Project and the Recreation and Public Access Project are presented from the projects come online (2015) through 2065.

3.3 Description of Other Potential Benefits

Long-term use of copper sulfate can lead to potential environmental problems. Over a period of years, copper carbonate will build up on the bottom of the lake that will inhibit growth of rooted bottom vegetation. Once rooted bottom vegetation can not grow due to the buildup of copper carbonate on the bottom, the nutrients that this vegetation would have tied up would now be available to stimulate excessive growth of algae. These potential environmental problems can be avoided by the Water Quality Project.

3.4 Description of the Distribution of Local, Regional, and State-Wide Benefits and Identification of Beneficiaries

The Water Quality, Ecosystem Restoration, and Recreation and Public Access Projects will provide local benefits by providing improved water quality and reduced treatment costs and better water supply reliability to the municipal drinking water system; improved aquatic habitat to the lake and downstream creek; and enhanced recreation and public access to Phoenix Lake lands. The beneficiaries of these improvements are the residents, businesses, property owners, and public agencies in the Towns of Ross and Larkspur and unincorporated communities of Kentfield, Greenbrae.

The Water Quality, Ecosystem Restoration, and Recreation and Public Access Projects will provide regional benefits to the greater Bay Area.

The Water Quality Project will provide regional benefits by improving the usability of Phoenix Lake and, hence, the reliability of MMWD’s local water supply source. As indicated in Attachment 8, Water Supply Benefits, to the extent that the reliability of MMWD’s local supplies are improved, and to the extent that the additional local supply created by the Project can replace imported supplies, the Water Supply Project will provide regional benefit to the greater Bay Area region. This benefit results from potentially reducing the need for MMWD to draw from the Russian River during severe shortages, as occurred during the late 1980s and early 1990s when the District drew surplus water through its supply connection with the Sonoma County Water Agency. The regional beneficiaries of reduced reliance on Russian River water during shortages are the water users of the Russian River, including the Sonoma County Water Agency and other users, as well as public resources that depend on adequate flows in the Russian River (e.g., special-status anadromous salmonid species, recreation). In addition, the Water Quality Project can provide statewide benefits by improving the reliability of MMWD's local water supply sources and thereby reducing the potential need to draw from the State Water Project during severe shortages, as occurred during the 1976-77 when State Project Water was transferred to MMWD via an emergency hook up to the EBMUD system. The Statewide beneficiaries of MMWD's reduced reliance on the State Water Project during an emergency are the users of the State Water Project, as well as public resources (e.g., anadromous salmonids, recreation) that depend on adequate flows in the rivers that supply the State Water Project.

The Ecosystem Restoration Project can provide regional and statewide benefits by contributing to the recovery of steelhead and coho salmon. Aquatic habitat conditions, specifically water temperature for summer rearing, would be improved in Ross Creek and Corte Madera Creek. These creeks are considered "anchor" streams in statewide plans for the recovery of these special-status species of fish.

The Recreation and Public Access Project can provide regional and statewide benefits by improving access to Phoenix Lake lands and enhancing the overall enjoyment of the lake to recreationalists and other visitors who use the lake. Fishermen, hikers, mountain bikers and other recreational visitors come from throughout the Bay Area region and Statewide, including disadvantaged and low-income areas, to enjoy Phoenix Lake.

3.5 When the Benefits Will be Received

As described in Attachment 5 (Schedule), construction of the Water Quality Project will be completed in 2016, and the Ecosystem Restoration Project and the Recreation and Public Access Project will be completed by the end of 2015. So, the benefits generated by the Water Quality Project will be received starting in 2017, and the benefits generated by the Ecosystem Restoration Project and the Recreation and Public Access Project will be received starting in 2016.

The facility components of the Water Quality Project (i.e., two circulation devices) are assumed to have a useful project life of 25-years and the facility components of the Ecosystem Restoration Project and the Recreation and Public Access Project are assumed to have a useful life of 50 years. Benefits for the three projects are calculated from the time the project comes online through their respective project life.

3.6 Uncertainty of the Benefits

The benefits of the Water Quality Project depend on the estimates of avoided use of copper sulfate and the future performance of the circulation devices. Existing water quality conditions have been examined based on available data, but further water quality testing will be needed as explained in Attachment 3, Workplan. It is possible that the circulation devices may not perform as planned due to currently unknown water quality issues or some other unforeseen factor. However, this possibility cannot be quantified. Further water quality tests will be examined and the viability of the circulation devices will be confirmed before they are purchased and installed.

The benefits of the Ecosystem Restoration Project have a moderate degree of certainty because the thermal stratification and availability of cool water in the lake hypolimnion has been confirmed through lake temperature profiling. However, some uncertainty still exists surrounding the hydraulic effects of withdrawing the cool water via the new intake at el. 140 ft. It is possible that the thermal stratification could be disturbed and warm water entrained in the withdrawal, particularly if the rate of withdrawal is high. This uncertainty will be examined as part of the preparation of the Coordinated Operations Plan based on information from the baseline water quality study of Phoenix Lake and instream flow study of Ross Creek.

The benefits of the Recreation and Public Access Project have a high degree of certainty. Phoenix Lake is known to be a highly used recreational area. Improvements to trails and road and visitor use facilities are likely to enhance visitors' recreational experience. Erosion sites and sources of sedimentation to Phoenix Lake have been thoroughly assessed and evaluated by MMWD in previous investigations. Remediation of these sites will likely provide the expected reductions in sediment delivery to the lake.

3.7 Description of Any Adverse Effects

There are no adverse effects anticipated from the implementation of the Water Quality Project and the Ecosystem Restoration Project.

There are no adverse effects anticipated from the implementation of the Recreation and Public Access Project with the exception of temporary construction-related impacts. Such impacts can include potential impacts on visitors. The potential impacts will be mitigated to a less-than-significant level.

Table 7 Water Quality and Other Expected Benefits (in 2009 Dollars) **Projects: Phoenix Lake IRWM Retrofit - Water Quality, Ecosystem Restoration, and Recreation/Public Access Projects**									
(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**
Year	**Type of Benefit***	**Measure of Benefit (Units)**	**Without Project**	**With Project**	**Change Resulting from Project (e)-(d)**	**Unit $ Value**	**Annual $ Value (f) × (g)**	**Discount Factor (1)**	**Discounted Benefit ($) (h) × (i)**
2009								1.000	
								1.000	
								1.000	
2010								0.943	
								0.943	
								0.943	
2011								0.890	
								0.890	
								0.890	
2012								0.840	
								0.840	
								0.840	
2013								0.792	
								0.792	
								0.792	
2014								0.747	
								0.747	
								0.747	
2015								0.705	
								0.705	
								0.705	
2016	a	pound						0.665	
	b	°C	23	12	-11			0.665	
	c	cubic yard	830	0	-830			0.665	
2017	a	pound	680	0	-680	6	4,080	0.627	2,558
	b	°C	23	12	-11			0.627	
	c	cubic yard	830	0	-830			0.627	
2018	a	pound	680	0	-680	6	4,080	0.592	2,415
	b	°C	23	12	-11			0.592	
	c	cubic yard	830	0	-830			0.592	
2019	a	pound	680	0	-680	6	4,080	0.558	2,277
	b	°C	23	12	-11			0.558	
	c	cubic yard	830	0	-830			0.558	
2020	a	pound	680	0	-680	6	4,080	0.527	2,150
	b	°C	23	12	-11			0.527	
	c	cubic yard	830	0	-830			0.527	
2021	a	pound	680	0	-680	6	4,080	0.497	2,028

	b	°C	23	12	-11			0.497	
	c	cubic yard	830	0	-830			0.497	
2022	a	pound	680	0	-680	6	4,080	0.469	1,914
	b	°C	23	12	-11			0.469	
	c	cubic yard	830	0	-830			0.469	
2023	a	pound	680	0	-680	6	4,080	0.442	1,803
	b	°C	23	12	-11			0.442	
	c	cubic yard	830	0	-830			0.442	
2024	a	pound	680	0	-680	6	4,080	0.417	1,701
	b	°C	23	12	-11			0.417	
	c	cubic yard	830	0	-830			0.417	
2025	a	pound	680	0	-680	6	4,080	0.394	1,608
	b	°C	23	12	-11			0.394	
	c	cubic yard	830	0	-830			0.394	
2026	a	pound	680	0	-680	6	4,080	0.371	1,514
	b	°C	23	12	-11			0.371	
	c	cubic yard	830	0	-830			0.371	
2027	a	pound	680	0	-680	6	4,080	0.350	1,428
	b	°C	23	12	-11			0.350	
	c	cubic yard	830	0	-830			0.350	
2028	a	pound	680	0	-680	6	4,080	0.331	1,350
	b	°C	23	12	-11			0.331	
	c	cubic yard	830	0	-830			0.331	
2029	a	pound	680	0	-680	6	4,080	0.312	1,273
	b	°C	23	12	-11			0.312	
	c	cubic yard	830	0	-830			0.312	
2030	a	pound	680	0	-680	6	4,080	0.294	1,200
	b	°C	23	12	-11			0.294	
	c	cubic yard	830	0	-830			0.294	
2031	a	pound	680	0	-680	6	4,080	0.278	1,134
	b	°C	23	12	-11			0.278	
	c	cubic yard	830	0	-830			0.278	
2032	a	pound	680	0	-680	6	4,080	0.262	1,069
	b	°C	23	12	-11			0.262	
	c	cubic yard	830	0	-830			0.262	
2033	a	pound	680	0	-680	6	4,080	0.247	1,008
	b	°C	23	12	-11			0.247	
	c	cubic yard	830	0	-830			0.247	
2034	a	pound	680	0	-680	6	4,080	0.233	951
	b	°C	23	12	-11			0.233	
	c	cubic yard	830	0	-830			0.233	
2035	a	pound	680	0	-680	6	4,080	0.220	898
	b	°C	23	12	-11			0.220	
	c	cubic yard	830	0	-830			0.220	
2036	a	pound	680	0	-680	6	4,080	0.207	845
	b	°C	23	12	-11			0.207	
	c	cubic yard	830	0	-830			0.207	
2037	a	pound	680	0	-680	6	4,080	0.196	800

	b	°C	23	12	-11			0.196	
	c	cubic yard	830	0	-830			0.196	
2038	a	pound	680	0	-680	6	4,080	0.185	755
	b	°C	23	12	-11			0.185	
	c	cubic yard	830	0	-830			0.185	
2039	a	pound	680	0	-680	6	4,080	0.174	710
	b	°C	23	12	-11			0.174	
	c	cubic yard	830	0	-830			0.174	
2040	a	pound	680	0	-680	6	4,080	0.164	669
	b	°C	23	12	-11			0.164	
	c	cubic yard	830	0	-830			0.164	
2041	a	pound	680	0	-680	6	4,080	0.155	632
	b	°C	23	12	-11			0.155	
	c	cubic yard	830	0	-830			0.155	
2042	a	pound	680	0	-680			0.146	
	b	°C	23	12	-11			0.146	
	c	cubic yard	830	0	-830			0.146	
2043	a	pound	680	0	-680			0.138	
	b	°C	23	12	-11			0.138	
	c	cubic yard	830	0	-830			0.138	
2044	a	pound	680	0	-680			0.130	
	b	°C	23	12	-11			0.130	
	c	cubic yard	830	0	-830			0.130	
2045	a	pound	680	0	-680			0.123	
	b	°C	23	12	-11			0.123	
	c	cubic yard	830	0	-830			0.123	
2046	a	pound	680	0	-680			0.116	
	b	°C	23	12	-11			0.116	
	c	cubic yard	830	0	-830			0.116	
2047	a	pound	680	0	-680			0.109	
	b	°C	23	12	-11			0.109	
	c	cubic yard	830	0	-830			0.109	
2048	a	pound	680	0	-680			0.103	
	b	°C	23	12	-11			0.103	
	c	cubic yard	830	0	-830			0.103	
2049	a	pound	680	0	-680			0.097	
	b	°C	23	12	-11			0.097	
	c	cubic yard	830	0	-830			0.097	
2050	a	pound	680	0	-680			0.092	
	b	°C	23	12	-11			0.092	
	c	cubic yard	830	0	-830			0.092	
2051	a	pound	680	0	-680			0.087	
	b	°C	23	12	-11			0.087	
	c	cubic yard	830	0	-830			0.087	
2052	a	pound	680	0	-680			0.082	
	b	°C	23	12	-11			0.082	
	c	cubic yard	830	0	-830			0.082	
2053	a	pound	680	0	-680			0.077	

	b	°C	23	12	-11			0.077	
	c	cubic yard	830	0	-830			0.077	
2054	a	pound	680	0	-680			0.073	
	b	°C	23	12	-11			0.073	
	c	cubic yard	830	0	-830			0.073	
2055	a	pound	680	0	-680			0.069	
	b	°C	23	12	-11			0.069	
	c	cubic yard	830	0	-830			0.069	
2056	a	pound	680	0	-680			0.065	
	b	°C	23	12	-11			0.065	
	c	cubic yard	830	0	-830			0.065	
2057	a	pound	680	0	-680			0.061	
	b	°C	23	12	-11			0.061	
	c	cubic yard	830	0	-830			0.061	
2058	a	pound	680	0	-680			0.058	
	b	°C	23	12	-11			0.058	
	c	cubic yard	830	0	-830			0.058	
2059	a	pound	680	0	-680			0.054	
	b	°C	23	12	-11			0.054	
	c	cubic yard	830	0	-830			0.054	
2060	a	pound	680	0	-680			0.051	
	b	°C	23	12	-11			0.051	
	c	cubic yard	830	0	-830			0.051	
2061	a	pound	680	0	-680			0.048	
	b	°C	23	12	-11			0.048	
	c	cubic yard	830	0	-830			0.048	
2062	a	pound	680	0	-680			0.046	
	b	°C	23	12	-11			0.046	
	c	cubic yard	830	0	-830			0.046	
2063	a	pound	680	0	-680			0.043	
	b	°C	23	12	-11			0.043	
	c	cubic yard	830	0	-830			0.043	
2064	a	pound	680	0	-680			0.041	
	b	°C	23	12	-11			0.041	
	c	cubic yard	830	0	-830			0.041	
2065	a	pound	680	0	-680			0.038	
	b	°C	23	12	-11			0.038	
	c	cubic yard	830	0	-830			0.038	
Total Present Value of Discounted Benefits Based on Unit Value (Sum of Column (j))									**34,000**

* Type of benefit:

a – avoid application of copper sulfate for algae control
b – reduced water temperature
c – reduced road-related sediment entering Phoenix Lake and its tributaries

(1) 6% discount rate.